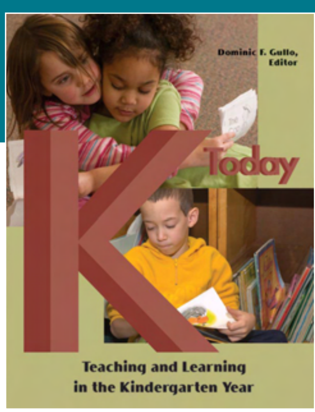
Developmentally Appropriate Practice

A reading from the CD accompanying *Developmentally Appropriate Practice in Early Childhood Programs Serving Children from Birth through Age 8, Third Edition.*

READING #56

Science in Kindergarten



Ingrid Chalufour and Karen Worth

Reprinted from *K Today,* chapter 9, 2006

CATEGORIES:

Curriculum: Science
Kindergarten

naeyc®

National Association for the Education of Young Children
www.naeyc.org

Science in Kindergarten

9

Ingrid Chalufour & Karen Worth

It's Monday morning. Twenty kindergarten children are sitting in a circle as their teacher, Derek, presents them with an interesting challenge:

> "I'm wondering how many ways you can think of to change the size and shape of your shadows. You'll all have a chance to work in our shadow theater this week, and then we'll talk about what you've discovered. There are paper and markers for you to keep track, and I'll be around to record your ideas, as well."
>
> The children have been exploring shadows for three weeks—outdoors on the playground, indoors with flashlights and different objects, and with a small shadow box. A shadow theater, a sheet hung from the ceiling with a gooseneck lamp on one side, was introduced the week before. The children are very excited to use their bodies and puppets to make shadows. This week, Derek wants the experimentation to be more intentional, so he gives the children this challenge at the beginning of choice time.
>
> During the week, the children explore the shadows they can make. Derek spends quite a bit of time with them observing, commenting, and asking questions. "How do you think you could make your shadow very small?" "What do you think would happen if we moved the lamp over to this side?" "Might your shadow look like a rock, just sitting there?" "You might like to draw what your shadow looks like when you stand sideways like that." "Let's write down what you did and where the lamp was."
>
> By the end of the week, there are many pictures with captions on the wall near the theater—pictures the children have drawn and photographs Derek has taken with his digital camera. These images become the focus for the science talk at the end of the week, after the children have pursued some of their ideas about shadows and how they change.

Over the weekend, Derek will produce a documentation panel with the pictures, the children's captions, and the ideas they have come up with. Derek plans to wrap up the shadow work the following week with a shadow theater presentation for families and other classes.

In another classroom, in the spring, Katie and her kindergartners have been studying plants and how they grow:

> While they watch grass sprouting and trees budding on the playground, they're growing a variety of things in the classroom. Windowsills and shelves are covered with potted plants, narcissus bulbs, garlic pieces, and carrot tops. The 21 children are gathered on the rug for their morning meeting, and 11 small foam trays are placed around the circle so the children can closely inspect the seedlings while they talk. The children are talking about what has been happening to the seedlings.
>
> Katie begins by reviewing the chart of observations from the previous week and then asks, "How

Ingrid Chalufour is a senior developer at Education Development Center, Inc. Karen Worth is a senior scientist in the Center for Science Education at Education Development Center, Inc., and an instructor of elementary education at Wheelock College.

have our seedlings changed since last week?" The children are eager to share their observations. "They're longer." "There are green leaves coming out on these." "This one is getting lots of things at the bottom." Katie writes their comments down on a chart with the date as she encourages specifics. "How do you know they're longer?" "Let's look at those leaves. The leaves on the kidney beans look different from the leaves on the lentils, don't they? How would you describe the difference?" "Does anyone know what we call the growth at the bottom of a plant? . . . Yes, it's called 'the roots.'"

Jamal is very interested in the growth of the seedlings. Katie decides it's time to begin measuring them. She asks Jamal to get the measurement basket, which has string, tape measures, and rulers in it. She quickly makes a chart they can use to record length over time. The children start filling in the chart by measuring three of the seedlings, then marking their length in inches on the chart in a column with the date on it. "I wonder how long these will be the next time we measure them?" "Do you think the kidney bean will always be the longest one? . . . What other changes do you think will happen?"

At the end of the discussion, Katie sets the stage for the day's choices. "There are several things you can do with these seedlings during choice time today. I'd like you to do a drawing in your journal. Draw the same seedlings you drew last time. I'll place the word cards at the table with your journals so you can use them to label your drawings. I'd also like some of you to do more charting of the seedlings' lengths. I think we could chart the growth of the bulbs, garlic, and carrots, as well." The children eagerly choose activities and choice time begins.

These examples give brief glimpses into the world of science teaching and learning that can and should take place in kindergarten classrooms. Three important questions must be answered in order for this teaching and learning to take place: What science should be taught? How should science curriculum be structured? How should it be taught? These questions lead to other questions: How much science should children do? What are the key instructional strategies teachers can use to promote learning? How can science fit into a program, given the typical kindergarten focus today on mathematics and literacy? The answers to some of these questions will be found in the following pages.

What science should we teach?

The National Science Education Standards (National Research Council 1996) and the *Benchmarks for Science Literacy* (AAAS 1993) describe what students should know and be able to do in science. These documents have provided guidance to many educators for a decade, but neither one addresses the kindergarten year; both start with first grade. Since the publication of these documents, a growing number of states have developed standards both for the preschool years and for kindergarten. However, given the current emphasis on mathematics and literacy, and the reality that science has never been a significant part of programs for young children, many of these standards do not include science. With little guidance for teachers and few expectations from the school system, the science teaching in kindergarten is often just a science table in a corner of the room with a few objects for children to look at or individual activities that they can do during choice time. The science that happens is often focused on the study of living things—classroom pets, plants, and nature walks—and it neglects the physical sciences. In too many classes science is not taught at all.

What follows is a framework for thinking about science content in the kindergarten classroom. There are many ways to organize the content of science for any level. We have chosen to turn to the national documents, the research on cognitive development, the practice of expert educators, and our own experience in the development of science curriculum materials. We have based the framework on five content areas: inquiry, life science, physical science, earth science, and space science.

Inquiry

Perhaps the most important area of science content is inquiry. In science, *inquiry* refers to the diverse ways in which scientists study the natural world and propose explanations based on the

evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (National Research Council 1996).

The box opposite lists important inquiry skills that kindergarten children must be given the opportunity to develop. They should be able to perform these skills at a simple level by the end of kindergarten. The two vignettes that opened this chapter include many examples of children using these skills as they explore shadows and the growth of seedlings.

One often sees such lists of inquiry skills in science programs and frameworks. They are frequently accompanied by the suggestion that the simpler skills of exploration, observation, and description and simple tool use are the most appropriate for younger children, and that the skills of investigation and experimentation and the more analytic synthesizing skills can only be learned as children get older. We suggest that kindergarten children can and do use *all* of the inquiry skills, but at a kindergarten level.

This is not a list of skills to be taught in isolation. Instead, it provides a practical guide for teachers to use as they design science experiences for children. Whatever the topic of study, all of the skills are used in the process of pursuing that study. In the flowchart on the next page, the inquiry skills are placed in a context, demonstrating that children's inquiry is a process, or a set of stages. The stages follow one another, with the arrows in the diagram suggesting that children will move back and forth between different stages depending on their interests, the challenges that arise, and the guidance of teachers.

Inquiry is about questions—but it is hard for children to ask questions about something if they haven't had a chance to get to know the thing or the event, whether it is shadows, seeds, snails, or water flow. So the first stage in the framework is to *notice, wonder, and explore.* This is a time for children to play, to see what they already know, to mess about in a rich environment with little direct guidance or structure. As children explore, they ask questions through words or actions. They may be struck by a particular idea or question, such as, "I wonder what will happen if I shine the flashlight on the car from the block corner?" These questions may lead them to *take action and extend questions,* the second stage in the framework.

It may not be possible to investigate many of the questions children raise. "Why does the seedling come out of the seed?" cannot be explored directly. "What is the name of this plant?" will not lead to lengthy discussion. But "What does the seedling need to grow?" has the beginnings of a rich investigation. At this stage, children often need adult guidance to begin to *focus observations*

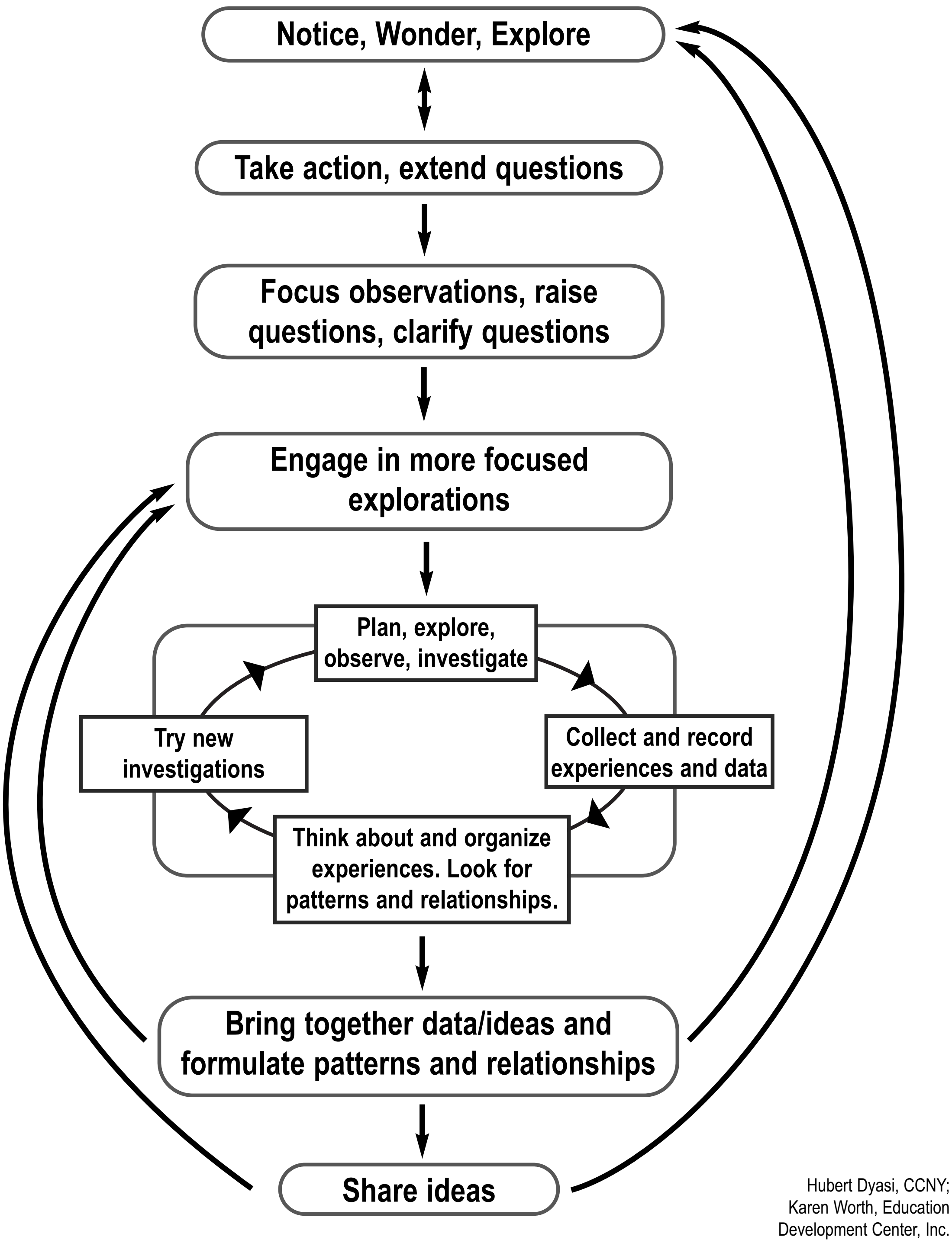
Important inquiry skills

As a result of their science experiences, kindergarten children should develop their abilities to:

- Raise questions about objects and events around them
- Explore materials, objects, and events by acting upon them and noticing what happens
- Use all senses to make careful observations of objects, organisms, and events
- Describe, compare, sort, classify, and order in terms of observable characteristics and properties
- Use a variety of simple tools to extend their observations (a hand lens, measuring tools, eye droppers, a balance)
- Engage in simple investigations including making predictions, gathering and interpreting data, recognizing simple patterns, and drawing conclusions
- Record observations, explanations, and ideas through multiple forms of representation including drawings, simple graphs, writing, and movement
- Work collaboratively with others
- Share and discuss ideas and listen to new perspectives

Source: From K. Worth & S. Grollman, *Worms, Shadows, and Whirlpools: Science in the Early Childhood Classroom* (Portsmouth, NH: Heinemann; Newton, MA: EDC; Washington, DC: NAEYC, 2003), 18. Reprinted with permission from Education Development Center, Inc. (EDC).

Young Children's Inquiry



and raise/clarify questions. They need to be encouraged to make some predictions about what might happen.

When children *engage in more focused explorations,* they are entering the experimental phase of inquiry. Given the right materials and teacher support and guidance, kindergarten children can do focused investigations. The framework presents this as a circular process, one that can go around and around. Children may explore a question for a long time, with their explorations leading to new questions and new investigations.

When children have a good deal of experience and begin to form some ideas, they need to step back from their hands-on investigative work, review and reflect on what they have done, and *bring together data/ideas and formulate patterns and relationships.* Young children's explanations and generalizations may be quite simple and naïve. What is important is that they draw from the experiences they have had and the data they have collected. New ideas in science are built on the knowledge of others.

The important last step of the framework is to *share ideas.* This is a time when children are encouraged to share what they have done, relate it to what others have done, discuss, and debate.

Yet inquiry skills cannot be acquired in a vacuum. Children need to inquire into something. So we turn to a list of basic ideas and topics in the four remaining content areas—life science, physical science, earth science, and space science.

Subject matter

Educators do not completely agree on the appropriate science subject matter for the kindergarten year. The criteria we use in developing science curriculum materials follow below. We include concepts or topics if they are:

- Drawn from the life, physical, and earth/space sciences as they are experienced by children in their daily lives
- Based on important science ideas
- Developmentally appropriate
- Accessible to children's direct exploration
- About things/events that children can explore deeply and over time
- Engaging, challenging, and fun

Topics such as dinosaurs, the solar system, or rain forests do not meet all of these criteria and are not appropriate for kindergarten science study. They are examples that are not drawn from children's lives and are not accessible to children's direct exploration. In addition, the underlying science of the history of the Earth, the structure of the solar system, and the complex interactions of the rain forest require a level of abstract thinking more appropriate for older students.

Applying the criteria yields the concepts and topics shown in the box on the next page. This list, however, is not intended to dictate what content must be covered in kindergarten. Rather, its purpose is to guide teachers, schools, or districts in choosing topics for a strong year-long program. Such a program must:

- Reflect the nature of the local environment and community
- Provide experiences drawn from the different content areas (not just from life science)
- Be limited enough to allow for in-depth inquiry in each topic

Further, the questions accompanying each topic or concept are simply to suggest the kinds of questions that children might explore. In many cases, especially in life science, a number of concepts might be part of a single study.

State standards may be more numerous and specific than the broad ideas outlined here but most will fit within one or another of these very basic ideas and topics. If state standards include other content, teachers will need to use the criteria provided to determine the most age-appropriate topics.

The big ideas

A carefully designed science program includes more than specific content. There are major understandings or ideas in science—sometimes called its *unifying concepts* or *big ideas.* These may not be taught directly, but should be the basis for curricu-

Key concepts and topics for the kindergarten year

Life science

Physical characteristics of living things

The basic needs of living things

Simple behaviors of living things

Relationship between living things and their environments—*What living things are there outside the classroom? What do they look like? How do they compare? What do they need to survive?*

The life cycle—*What happens to a seed as it grows and develops? What things make a difference in how it grows? What changes do animals go through as they grow?*

Variation and diversity—*What are all the living things we can find in a small plot? Are they the same? Are they different?*

People—*How are we all alike? How are we different? What do our senses tell us?*

Physical science

Properties of objects and materials

- Properties of solids—*What are the properties of our rocks? What are the properties of the soils? What are the properties of the leaves we collected? What are the properties of the different blocks we are building with?*
- Properties of liquids—*How does water move? How can water go up? What are drops like? How do they move? What happens to water when it is left in an open container? Frozen?*

Position and motion of objects—*How far will the ball go when it rolls down different ramps? What difference does it make if a ball is large or small? Heavy or light?*

Properties and characteristics of sound—*What kinds of sounds do different things make? How can sound be made louder? Softer? How can the pitch of a sound be changed?*

Properties and characteristics of light—*What happens to a shadow when a light moves? How many different shadows can be made with a light and an object?*

Earth science

Properties of Earth materials—*What is the ground like outside our classroom? What is in the soil?*

Weather—*What are the features of weather, and how can they be measured? What are the patterns of weather over a week? A month? A year?*

Space science

Patterns of movement and change of the Moon and Sun—*How does the Sun move across the sky? Is it the same every day? How does the shape of the Moon seem to change? Is there a pattern?*

lum planning. For kindergarten children, these big ideas include looking for patterns, seeing relationships, noticing change, identifying cause and effect, and seeing how form is related to function.

Attitudes and dispositions

Finally, a rich kindergarten science program supports the development of certain attitudes and dispositions that are important in all areas of learning. These include:

- Curiosity
- Seeing oneself as a learner of science
- Respect for life
- Willingness to take risks
- Perseverance
- Respect for evidence
- Willingness to collaborate

How should science curriculum be structured?

Let us look back at the two vignettes and see how these four components of a rich science program—inquiry, subject matter, big ideas, and attitudes—come together in curriculum.

Putting it all together

In the first vignette, Derek has gone to his state standards and selected light and shadow as his subject matter. He has identified these concepts: light travels from a source; light can be blocked by objects; when light is blocked by something, there is a shadow; and the size and shape of shadows change if the light source or object is moved. Katie has chosen plants as her subject matter. She has identified that plants have a life cycle, plants have basic needs that must be met if they are to survive, plants develop and grow in predictable ways, and there is variation in the way seeds grow.

Derek and Katie have provided the children with many materials that allow them to inquire. In Derek's class, the children explore and notice what shadows and lights do, both indoors and outdoors. They describe what is happening and talk about their ideas. They use shadow boxes and the theater for simple investigations that follow up on their own questions and respond to Derek's challenge. Representation (drawing, writing, making models) is a constant part of the children's work, as are the science talks that help them draw out their ideas and conclusions. Katie's classroom is also engaged in a study that is taking place indoors and outdoors with many different kinds of plants. They are using simple tools—the magnifier and measuring tools—as part of their investigation of the growth of seedlings. As they collect and record their observations using graphs, drawings, and words over a couple of weeks, they continuously analyze the data looking for patterns and relationships, and they talk about their thinking.

Derek keeps the big ideas in mind as he interacts with children during their investigations and guides the science talks. He asks the children about relationships—in this case, the relationship between the light and the objects they are using and the shadows. Together he and the children wonder about cause and effect—what causes a shadow's size and shape and how they can control the effect. Katie considers the patterns of growth the children are watching. Rather than just naming parts of the plant, she talks about change—how the plants are changing and what functions new parts might serve and the relationship between form and function.

Finally, the materials and the events invite the children to question, to develop important attitudes and dispositions such as curiosity, a sense of themselves as science learners, perseverance, and collaboration. As Derek and Katie pose questions and challenge children to develop and share their own ideas, they are creating an environment in which learning science is an active and rigorous process that everyone can do, and a process that is based in the data they collect. This environment and culture also support children as they try out new actions and ideas. Children discover that sometimes things fall down or a light goes out, and they have to start again. They learn that they must work together—to investigate different shadows, one person has to hold the flashlight while another moves the object.

A simple framework

Each science study or investigation takes on a life of its own based on the content and the topic that is selected. But a science study has a simple structure that is useful to consider: engagement, focused exploration, extending the investigation through books and other media, and connecting to home and community.

Most studies begin with time for children to *become familiar* with the materials and events they will explore more deeply and pose some initial questions. A science study then moves on to *more focused exploration,* where the teacher challenges children to go deeper, to build understanding, and to document their work. Guided by the goals she has set, the teacher creates a focus using a child's question or one of her own.

> The teacher's guidance of children's hands-on explorations is essential to the success of any science investigation.

A third part of this framework lies in the use of books and other media to *extend and enrich the firsthand experience.* Once they have grown seeds and studied the plants outside their classroom, children may be transported to a different plant world with a book on the giant redwoods. Once they have explored what the plants in their neighborhood need, they can read about desert plants and how they survive to learn more about basic needs and habitats. Reading a story about a scientist helps them to understand how scientists inquire.

Finally, the structure of a science study includes the *interplay between classroom, community, and home.* If science consists of activities only in the classroom, children will be less likely to see themselves as learners of science outside the classroom. Children and teachers can take trips to a plant nursery or science museum. Parents and community members with experience and expertise can be invited into the classroom. Teachers can send children home with letters that offer simple ways to support continued investigation at home.

How should science be taught?

Teaching inquiry-based science carries particular responsibilities for the teacher. Derek and Katie both demonstrate a variety of roles that promote science learning. They are both clear about the goals they have for learning and how their actions relate to those goals. They also have embedded the skills and the attitudes of inquiry into the daily routine of their classrooms. The children actively investigate. They record and discuss their experiences and observations. Teachers who engage a class in science inquiry play the following four roles:

Designing a science-rich environment

Direct hands-on exploration lies at the heart of inquiry, and effective teachers design the learning environment to stimulate and support children's exploration. To create this learning environment, teachers begin by making decisions about the central concepts. For example, a teacher may decide to focus on properties of liquids and, more specifically, on water flow and water drops. Then they select materials, carefully create spaces for exploration, and design the schedule.

Selecting materials. The materials for children's exploration must connect directly to the core science learning goals. This means that teachers may have to remove materials as well as add them. Children may not be able to focus on the science of water flow when there are dolls and dishes in the water table. Materials must be plentiful, too. For example, each pair of students needs a flashlight to work with light and shadows. Basic science tools such as magnifiers, measuring instruments, and containers should be part of all classrooms.

Teachers also need to consider what materials to provide for documentation and representation. Books and other resources, such as pictures or posters, strategically placed around the room stimulate children's inquiry and provide them with needed information.

Teachers may worry, "I can't get all the materials needed for science."

With time and money limited, it can be difficult to get the varied materials needed for science inquiry. However, many of the materials of science are free or inexpensive. Nearby recycle centers are very useful. Printing stores, lumber yards, brick and gravel companies, and other businesses often will give away remainders and scraps. Members of the community might donate materials or money. Laboratories, science centers, colleges, and even high schools might give or loan materials. Libraries and the Internet offer free media resources.

Creating space for exploration. There are several ways to think about space. Teachers might have to temporarily rearrange a room in order to provide adequate space. For example, Derek uses his block area for the shadow theater. Katie dedicates several parts of her room to science so more children can participate. She puts the seedlings on one table and potted plants on the windowsill. Children keep track of the sprouting carrot tops and the potato on another table. It is also important to think about the way that display space can serve to stimulate and inform children's work. Posters, pictures, charts, documentation panels, and representations displayed at children's eye level help them revisit and build on their previous work and lead to new investigations. Finally, it is important to think about space beyond the classroom. Teachers extend children's learning by making connections between classroom investigations and the immediate environment of the school or community.

Teachers may express the concern, "I don't have any space to do this."

Many classrooms are small. Some have limited wall space. There may be only blacktopped playgrounds outside the school. However, any room can temporarily be rearranged, borrowing from one area to add to another. Displays can be set up on the back of a cabinet or on an extra easel. Checking beyond the school yard can turn up places to expand investigations.

Designing the schedule. In-depth investigations take time. It can take weeks, even a month or two, for children to engage deeply with a topic and build new understandings. Some studies—such as weather patterns or how the world outside changes from season to season—can last all year. Regular choice times— at least 45 minutes of uninterrupted time—allow children to get engaged, see through an exploration, and spend some time representing their experience. Children also need regular opportunities to share their experiences and explore the patterns that emerge as they put a series of experiences together. This can happen at morning meetings, at circle time, and in small groups during choice time.

Teachers may worry, "I have to cover so many things. I have no time for science."

Classroom time pressures are very real. The emphasis on standards and basic skills in literacy and mathematics encourages teachers to view the daily schedule as a series of subject-specific activities. But time might be best spent by integrating competing demands. Katie's teaching is a good example. She makes science central to her kindergarten day. She emphasizes the role of documentation. The children chart, make observational drawings, and label. They learn the concepts of print, the connection between sound and print, and how to use print to label and explain their experiences and ideas. The children also have a variety of books available—from instructional books on how to grow plants to fiction such as *The Carrot Seed* (by Ruth Krauss). Katie also incorporates appropriate mathematics learning into the data-collection process. The children measure and discuss the seedlings. In the process, they build a vocabulary for discussing relative size and shape. They develop an understanding of numbers, number patterns, relationships, and the use of measurement to provide comparative data.

Guiding children's hands-on explorations

The teacher's guidance of children's hands-on explorations is essential to the success of any science investigation. While the environment does a lot of the work, the teacher's encouragement, guidance, probing, and challenges are vital to children's learning.

Setting the stage. A teacher's introduction to the day's science activities helps children focus on important science concepts. Ways to do that include these:

- Use documents from the previous day. Katie's children's growth charts provide opportunities to stimulate new investigations or extensions of previous experiences.
- Show children new materials and ask what they might do with them. "I have these new blocks. Feel them. What do you think you might build with these?"
- Offer a challenge. Derek introduces the shadow theater and challenges the children to make different shadows. A new investigation is launched.

Closely observe children's engagement. Once children begin to work, teachers need to watch their interactions with the materials and each other. These observations form the basis for selecting interventions that are relevant to what the children are doing and thinking and that improve their understanding. For example, Derek observed his children looking at the shadow of the flag pole in the playground and suggested they might look at it at different times of the day to see if it stayed the same.

Maximize engagement. Early in a topic, teachers need to notice who is engaged and who is not. Teachers should provide encouragement to any children who remain unengaged after several days. With knowledge of the children's interests, learning styles, background knowledge, and experiences, teachers can attempt to connect them with the exploration. Children who are reticent to interact with the materials might feel more comfortable taking on a documentation role at first. Others may need help learning to use the materials. Or, the teacher may need to add materials so that more children can be engaged.

Focus attention on the science. Teachers can use strategic comments or questions to help children focus on the science they are experiencing. "I notice that the roots of your seedlings are different lengths." Or, "I wonder how you made the shadow of the crayon look shorter." These kinds of comments heighten the children's attention to their science experience.

Extend children's learning. When the teacher's goal is to extend the exploration, these interactions will go further. For example, Katie might ask a child to measure the roots of the seedlings every other day to see what happens. Derek might select several objects and then ask a child to make three differently shaped shadows with each.

Deepening children's understanding

Experiences are the basis of science learning, but reflection on those experiences is what leads children to modify any previous naïve beliefs to form more sophisticated theories. Representation and discussion are two primary ways to encourage children's reflection.

Representation. The use of various media to reflect on and communicate experiences, observations and ideas is termed *representation.* Children learn to communicate in a variety of ways when they have regular opportunities to represent their experiences and ideas. Representation gives children a chance to reflect on a recent experience. They can think about the elements that were important to them, and ultimately gain new understandings of the science they are exploring (Wells 1986). Teachers encourage representation by:

- Making representation a regular part of the classroom routine
- Selecting materials that allow for an accurate representation of the object or experience and that provide opportunities for movement and story telling
- Providing easy access to materials where the science exploration takes place
- Building special times for representation into the schedule
- Valuing all children's work
- Talking with individuals about what they have done

Teachers may say, "But my children can't write."

Even at the beginning of the year, all kindergarten children can put something down on a piece of paper or in a science notebook. They can draw, they can begin to label drawings, and they can start to put letters down for words. The desire

to represent the science work they have done may motivate some children to develop and use initial writing skills.

Discussions. A group discussion stimulates and makes explicit the thinking processes that underlie inquiry. They help build a shared vocabulary and encourage collaboration. Teachers can engage small groups in retelling the steps in their investigation, analyzing the data they have collected, or solving a problem. In large groups, children can share experiences, compare and contrast what they have found out, try out a new explanation, and ask a new question. Teachers guide meaningful conversations by:

- Keeping the dialogue open ended, accepting all contributions
- Maintaining a focus on the important science concepts that are being explored
- Probing for additional observations, more specifics, and alternate points of view
- Asking children: "Why do you think?" "How do you know?"
- Giving children time to think before expecting them to speak
- Using children's work and teacher documentation to encourage children to think back on what they have done and ideas they may have
- Asking children to comment on and question each other's experiences and ideas
- Avoiding explaining the science or looking for a right answer

Teachers may protest, "My kids won't sit still and don't listen to one another."

Children need to learn discussion skills and norms. They need to be taught explicitly how to listen and how to ask a question of another child. Sitting in a circle facing one another sets the stage. Discussions should be kept short at the beginning of the year. When children have discussions regularly, their participation will increase over time.

Using ongoing assessment to inform teaching

Children's engagement and learning is contingent on the relevance of what is being taught, and whether the learning opportunities match the level of their skills and understanding. Teachers can build a relevant curriculum through ongoing assessment. Important considerations include these:

What do you expect the children to do and learn? An essential step in assessing teaching and learning is to identify the learning goals related to each topic. These include both the conceptual learning goals and the inquiry goals.

How will the children display new understandings and skills? Children's understandings are best revealed as they explore, represent, and talk. Their ideas are often evident in their interactions with materials. For example, what process does a particular child go through to make a shadow smaller? Does he go through a lot of trial and error before he finds a successful strategy? Is he able to use past experiences to come to a solution quickly? Children's understandings are also revealed in their representational work. Have they included all of the parts of their seedling in their drawings? Can they talk about the seedlings' parts using accurate terms for the roots, stem, and leaves?

> Children's understandings are best revealed as they explore, represent, and talk.

What questions are revealed in their work? Ongoing assessment is sometimes called "formative" assessment because the knowledge the teacher gains from the assessment helps him to determine what to do next. Often the assessment will uncover questions children are asking, in action or in words, which can then be used as the focus for another investigation. For example, while the children are investigating ways to change the size of shadows, Derek might observe that they show their interest in the varying shadows by using different materials. They may be curious about the materials that do or do not let some light through. This might serve as an excellent investigation for the future. Or, the teacher may realize that children are still struggling with a concept and need more time before moving on.

❖ ❖ ❖

Science is very important for kindergarten children for many reasons. Young children are naturally curious about their environment and are struggling to make sense of the world around them. A good science program engages all children in a way that builds on this natural curiosity, supports their attitudes and dispositions toward learning, and fosters inquiry skills. In addition to setting the foundation for later science learning, science investigations support other curriculum areas by providing many opportunities for developing literacy skills, applying mathematical ideas, and working together.

In this chapter, we have looked at appropriate goals for kindergarten children in science knowledge and abilities. We have emphasized the need for in-depth, long-term science studies that provide all children with the opportunities they need to develop an understanding of ideas and the nature of inquiry. We have looked at the teacher's role, highlighting the importance of the learning environment; the strategies that guide and challenge children's hands-on work; and perhaps most important, the strategies that teachers use to help children reflect on their experiences and develop science reasoning through discussion, representation, and documentation.

References

AAAS (American Association for the Advancement of Science). 1993. *Benchmarks for science literacy*. New York: Oxford University Press.

National Research Council. 1996. *National science education standards*. Washington, DC: National Academies Press.

Wells, G. 1986. *The meaning makers.* Portsmouth, NH: Heinemann.

Worth, K., & S. Grollman. 2003. *Worms, shadows, and whirlpools: Science in the early childhood classroom*. Portsmouth, NH: Heinemann; Newton, MA: EDC; Washington, DC: NAEYC.